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Sincerely yours,

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SIXTH INTERIM ENGINEERING REPORT
4.14
TECHNIQUES FOR SENSITIVITY IMPROVEMENT OF CRYSTAL VIDEO RECEIVERS

Report Period: 27 Feb to 27 May 1957
Contract AF30(602)-1435, Project No. 4505
Task No. 45215

Rome Air Development Center
Griffiss Air Force Base
Rome, New York

Contributors: ______________________ Date ______________
R. M. Miller, Engineer

______________________ Date ______________
S.J. Blanchard, Section Head

Approved: ______________________ Date ______________
M.J. DiToro, Director of Engineering

POLYTECHNIC RESEARCH & DEVELOPMENT CO., INC.
202 Tillary St., Brooklyn 1, New York

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______________________ Date ____________
S.J. Blanchard, Section Head

Approved: ______________________ Date ____________
M.J. DiToro, Director of Engineering

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Polytechnic Research & Development Co., Inc. Contract AF30(602)-1435
Sixth Quarterly Engineering Report, for 27 Feb to 27 May 1957.

CONTENTS

Section		Page
1	Abstract	3
	PART I	
2	Purpose	3
3	General Factual Data	3
3.1	Personnel	3
3.2	Patents	3
4	Detailed Factual Data	3
4.1	Work Schedule	4
4.2	Backward Wave Amplifier Characteristics	4
4.3	Video Amplifier	6
4.4	Breadboard Model of Receiver	6
5	Conclusions	7
	PART II	
6	Program for the Next Interval	7
	PART III	
	ILLUSTRATIONS	
Figure 1	Frequency vs Helix Voltage for Sylvania Type 532 BWA	8
2	DC Circuit of Sylvania Type 532 BWA	9
3	Start Oscillation Current for Sylvania Type 532 BWA	10
4	Block Diagram for Performance Tests on Sylvania Type 532 BWA	11
5	Gain vs Power Output for Sylvania Type 532 BWA	12
6	Bandwidth vs Power Input for Sylvania Type 532 BWA	13
7	Video Amplifier	14
8	Swept Crystal Video Receiver	15
9	Block Diagram for Receiver Sensitivity Measurement	16
10	Receiver Sensitivity vs Frequency with Sylvania Type 532 BWA	17
11	Receiver Sensitivity vs Frequency with BWA Shorted	18

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Polytechnic Rsearch & Development Co., Inc Contract AF30(602)-1435
Sixth Quarterly Engineering Report, for 27 Feb to 27 May 1957

1. ABSTRACT

Progress is reported on the testing of components for a swept crystal video receiver employing a backward-wave amplifier (BWA). The results of preliminary laboratory tests are included on the characteristics of the Sylvania Type 532 BWA Experimental data on receiver sensitivity are shown to be in close agreement with theoretical expectations.

PART I

2. PURPOSE

The purpose of this project is the development of techniques for improving the sensitivity of crystal video receivers in the 1000-to-15,000 mc frequency range Specifically, the investigation is intended to determine the extent to which the following performance characteristics can be achieved: minimum detectable signal of -85 dbm; substantially flat response over an octave frequency range; 5% frequency resolution, and high probability of intercept for pulsed signals having pulse durations of 0.25 to 10 μsec and repetition rates of 100 to 5000 pps.

3. GENERAL FACTUAL DATA

3.1 PERSONNEL The technical personnel and time devoted to this project during the report period are as follows:

N. Rothenberg . . . . 32 hours
S.J. Blanchard. . . . 85.5
R. Miller 120

3.2 PATENTS. No patent applications or patents held by the contractor are considered applicable to the present project. However, certain ideas set forth in the proposal, which was written before the contract was awarded, are considered propriety and may be incorporated in a patent specification at some future date.

4. DETAILED FACTUAL DATA

There was relatively little activity during the first part of this reporting period due to the delay in the receipt of the Type 532 BWA from Sylvania Electric Products Company.

4.1 WORK SCHEDULE. The schedule for work on the various phases of the project and the percentage of the work completed are shown in table 1.

4.2 BACKWARD WAVE AMPLIFIER CHARACTERISTICS. The frequency vs helix voltage characteristic curve for the two Sylvania Type 532 BWA tubes are shown in figure 1. One of these tubes, Serial 496, was purchased directly from Sylvania Electric Products, Mountain View, California; the other tube, Serial 306, is government-furnished equipment obtained from RADC. Some data were provided with each tube.

The supply voltages were applied to the BWA's as shown in figure 2. Since the center conductor of the r-f cables is the d-c helix connection it is necessary to ground the center conductor at some point. This was effected by shorting the third leg of a "T" which was connected at the output of the tube.

The BWA's were operated under the following conditions:

	No. 496	No. 306
Heater Voltage, E_f	6.3 Vac	6.3 Vac
Collector Voltage, E_{COL} (with respect to helix)	150 Vdc	80 Vdc
Helix Voltage, E_H (with respect to cathode)	200 to 600 Vdc	200 to 600 Vdc
Anode Voltage, E_{A1} (with respect to cathode)	20 to 30 Vdc	45 to 75 Vdc

Being modified backward-wave oscillators, these tubes require careful adjustment of the control voltages at each frequency to prevent oscillation. In order to obtain reasonably consistent tube performance over the octave frequency band, the cathode current must be maintained at some fixed percentage of that value of cathode current for which the BWA becomes unstable. This value of cathode current will be referred to as the start-oscillation cathode current or simply I_{SO}. The value of cathode current was adjusted by means of the anode voltage, E_{A1}. As can be seen from figure 3, the start-oscillation current varies with frequency. For most of the measurements the cathode current was adjusted to 0.9 I_{SO}.

The BWA was connected to a 2-to-4-kmc pulsed r-f source as shown in figure 4 and the detected output was monitored on an oscilloscope. A heterodyne-type frequency meter was used to measure frequency, and the power level was determined by a power bridge and calibrated attenuator.

The curve of gain vs output power of figure 5 indicates that the tube begins to saturate when the output power exceeds 1 milliwatt.

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Table 1

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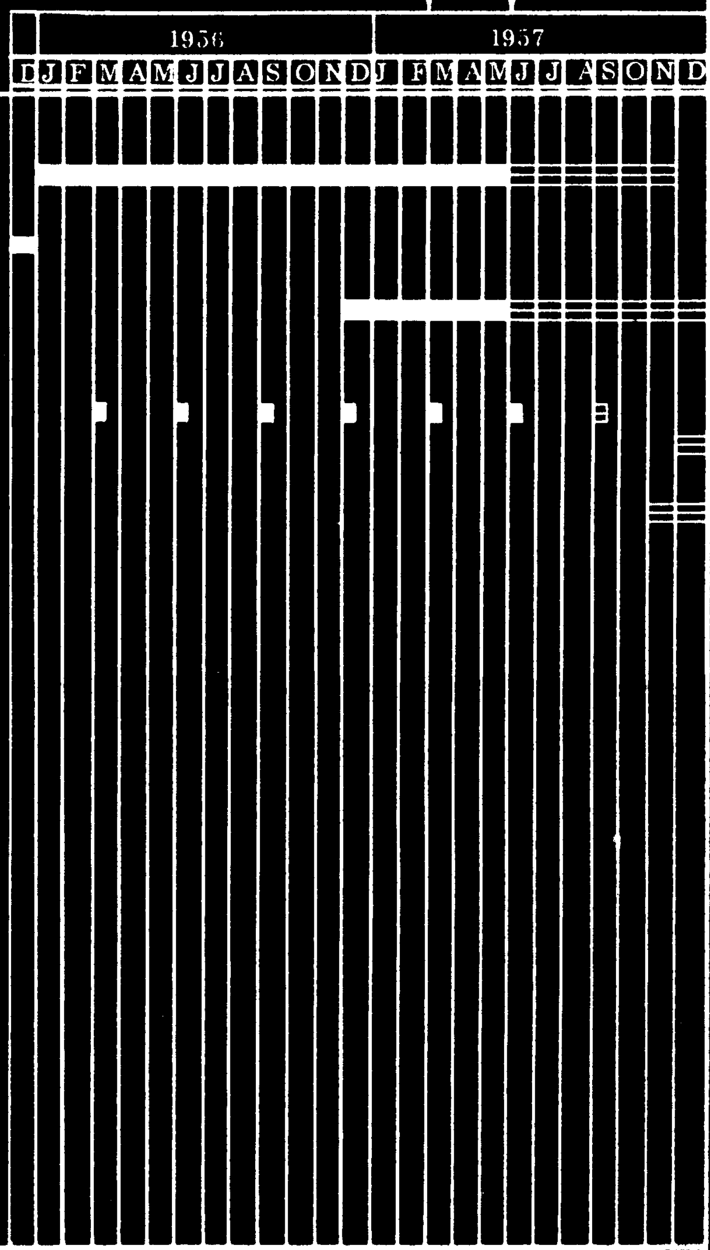
PROJECT PERFORMANCE AND SCHEDULE

Contract No. AF30(602)-1435
Project No. 4505, Task No. 45215

Period Covered
28 Feb to
27 May 1957

	Est'd. Compl'n
1. Study & Experimental Investigation	85%
2. Literature Survey	96%
3. Breadboard Model	50%
4. Reports	
a. Quarterly	85%
b. Final	0%
5. Miscellaneous	0%



Work Performed

Schedule of
Projected Operation

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Figure 6 is a plot of the BWA 3-db bandwidth vs input power. It is seen that the bandwidth gradually increases with increasing power. The data collected on both BWA's are in general agreement with the information supplied by Sylvania.

4.3 VIDEO AMPLIFIER The output stage of the video amplifier was modified to accommodate a larger dynamic range of output signal. The modified schematic is shown in figure 7.

4.4. BREADBOARD MODEL OF RECEIVER. As explained in the previous quarterly report, the Sylvania Type 532 BWA is the principal component in the swept crystal video receiver, figure 8.

4.4.1 RECEIVER SENSITIVITY. Receiver-sensitivity measurements were made with the test equipment shown in figure 9. A pulse-modulated r-f signal between 2 and 4 kmc was applied to the receiver input. The frequency was monitored with the PRD Type 504 Precision Heterodyne Frequency Meter and the power input was measured with the PRD Type 650B Universal Power Bridge.

During these preliminary tests the BWA was not operated under swept conditions. The receiver was tuned to the incoming signal frequency by properly setting the BWA helix voltage. At the same time, the anode voltage was adjusted to give a BWA cathode current of 0.9 I_{so} for that particular frequency.

A curve of receiver tangential sensitivity vs frequency is plotted in figure 10 over a limited frequency range. Also included for comparison on the same graph is a plot of the theoretical receiver sensitivity. Data for this curve was obtained from equation 5 of the Interim Report for the period 28 August to 27 November 1956, namely

$$P_{min} = KTF\left(2B_V + \sqrt{3B_V^2 + 2B_I B_V}\right)$$

The 3-db bandwidth, or 2.7 mc, was used as the video bandwidth, B_V. (The frequency response of the video amplifier is given in figure 5 of the Fifth Interim Engineering Report.) A very wide-band oscilloscope was employed for viewing the receiver output so that the video bandwidth was determined solely by the video amplifier of the receiver. The receiver noise figure, F, was assumed to be the same as the noise figure of the low-noise TWT, which is Model 511 Serial No. 12 of the Alfred Electronics Company. The noise figure vs frequency for this TWT is plotted in figure 2 of the Fifth Interim Report. Since we do not yet have data on the bandwidth of the BWA, B_1 was taken as 10 mc.

The experimental and calculated values of receiver sensitivity agree within the bounds of measurement error. In the calculation of the theoretical values it is assumed that for tangential sensitivity the signal is 3 db above noise.

In figure 11 the backward wave amplifier is removed so that there remains a simple crystal video receiver with preamplification. Again, a plot of both the calculated and measured receiver sensitivity is included. Data for the theoretical curve was obtained from equation 9 of the Interim Report for the period 28 February to 27 May 1956.

5. CONCLUSIONS.

Experience obtained in the laboratory indicates that the characteristics of the Sylvania Type 532 BWA change with time. The gain and bandwidth of this tube are functions of the signal level, frequency, and cathode current. Inasmuch as the start-oscillation current varies greatly with frequency, a swept receiver incorporating this BWA must include means for tracking the anode voltage with the collector-delay-line voltage.

Preliminary data on receiver sensitivity are in good agreement with theory.

PART II

6. PROGRAM FOR THE NEXT INTERVAL

6.1 Complete experimental data will be collected on the performance characteristics of the Sylvania Type 532 BWA Serial No's 306 and 496.

6.2 The swept crystal video receiver will be investigated experimentally in more detail. Sensitivity and dynamic range will be checked and the system will be studied to determine the accuracy with which frequency may be determined.

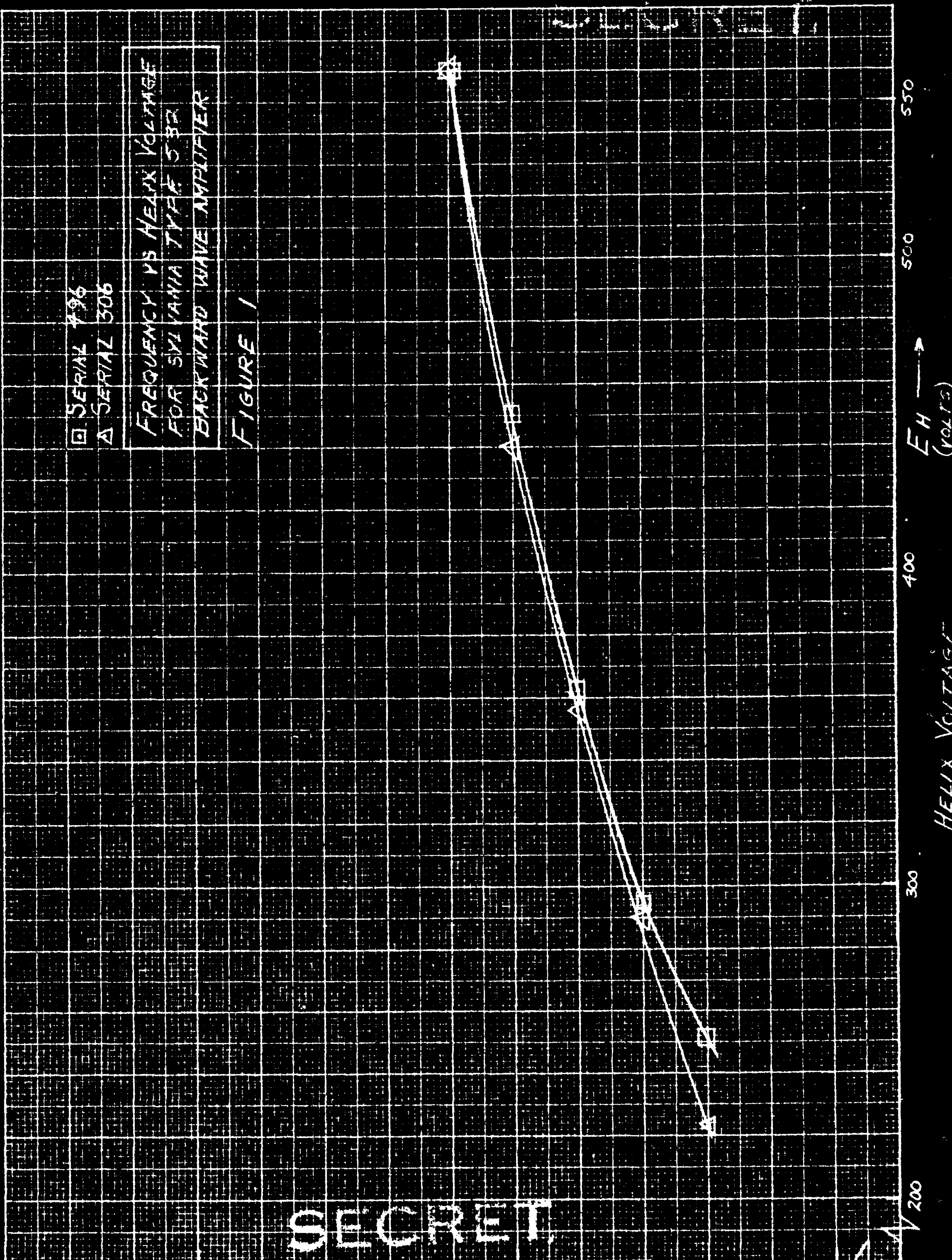

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FIGURE 2 D-C CIRCUIT OF SYLVANIA TYPE 532 BWA

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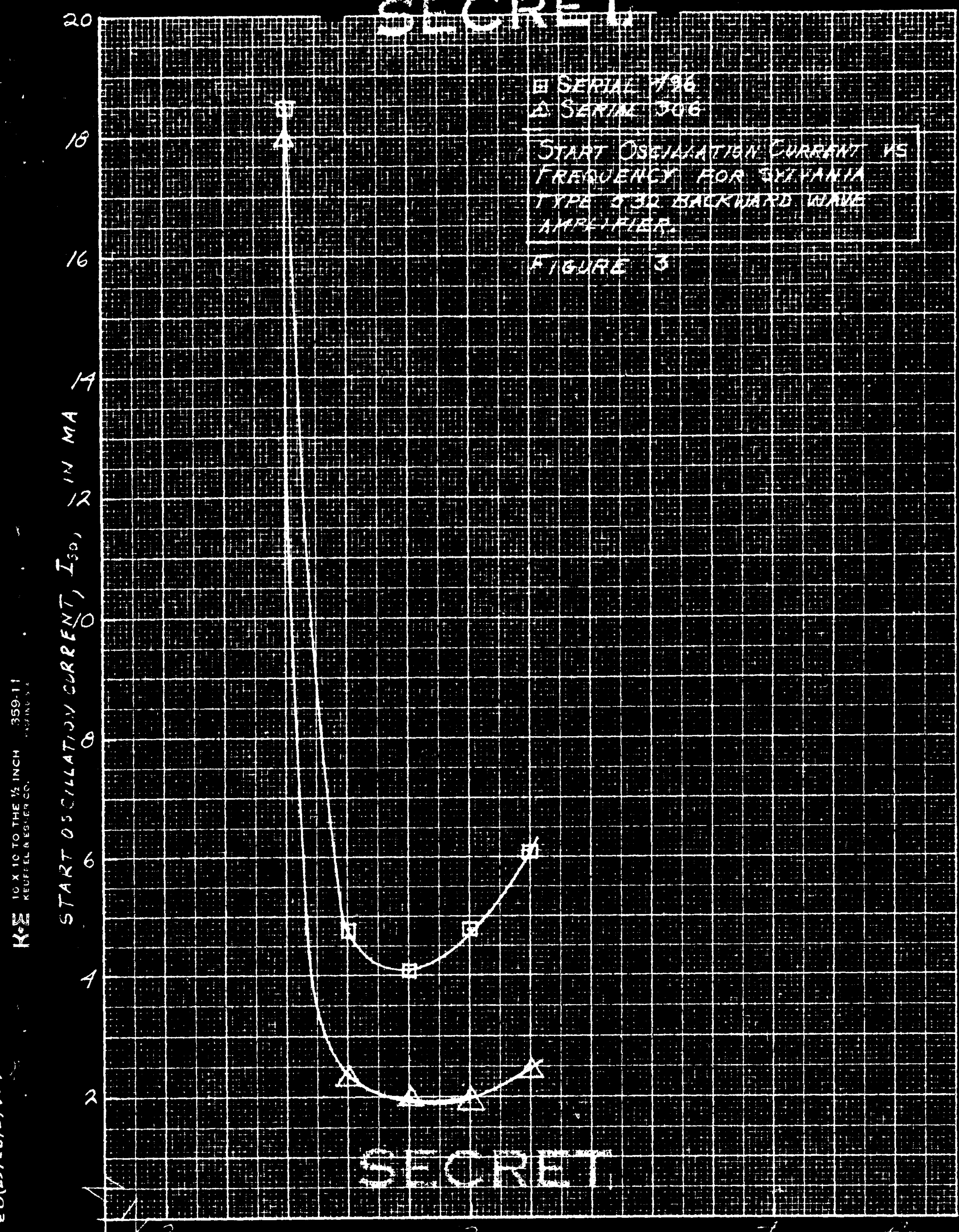

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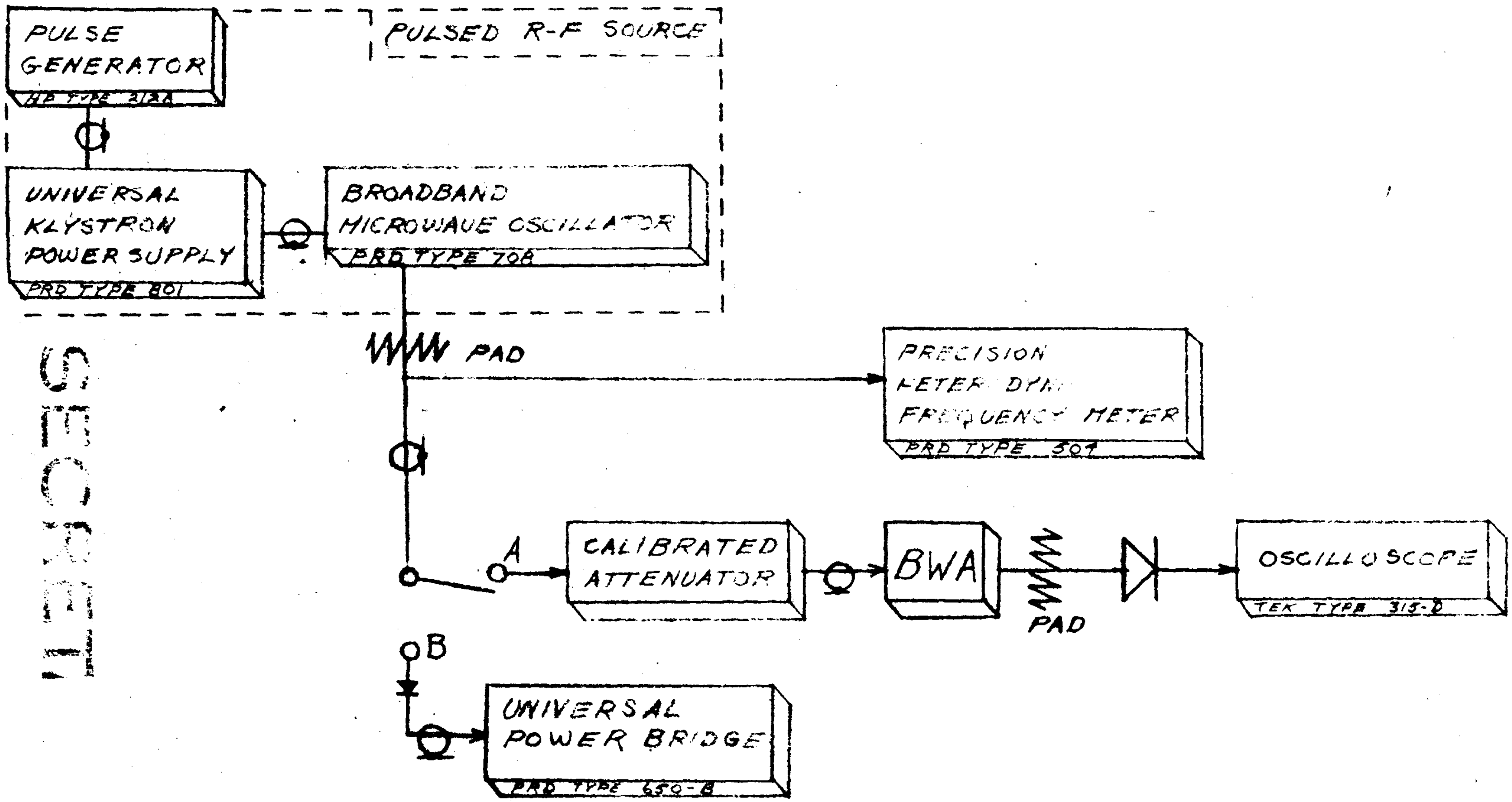

FIGURE 4 PERFORMANCE TESTS ON SYLVANIA TYPE 532 BACKWARD WAVE AMPLIFIER

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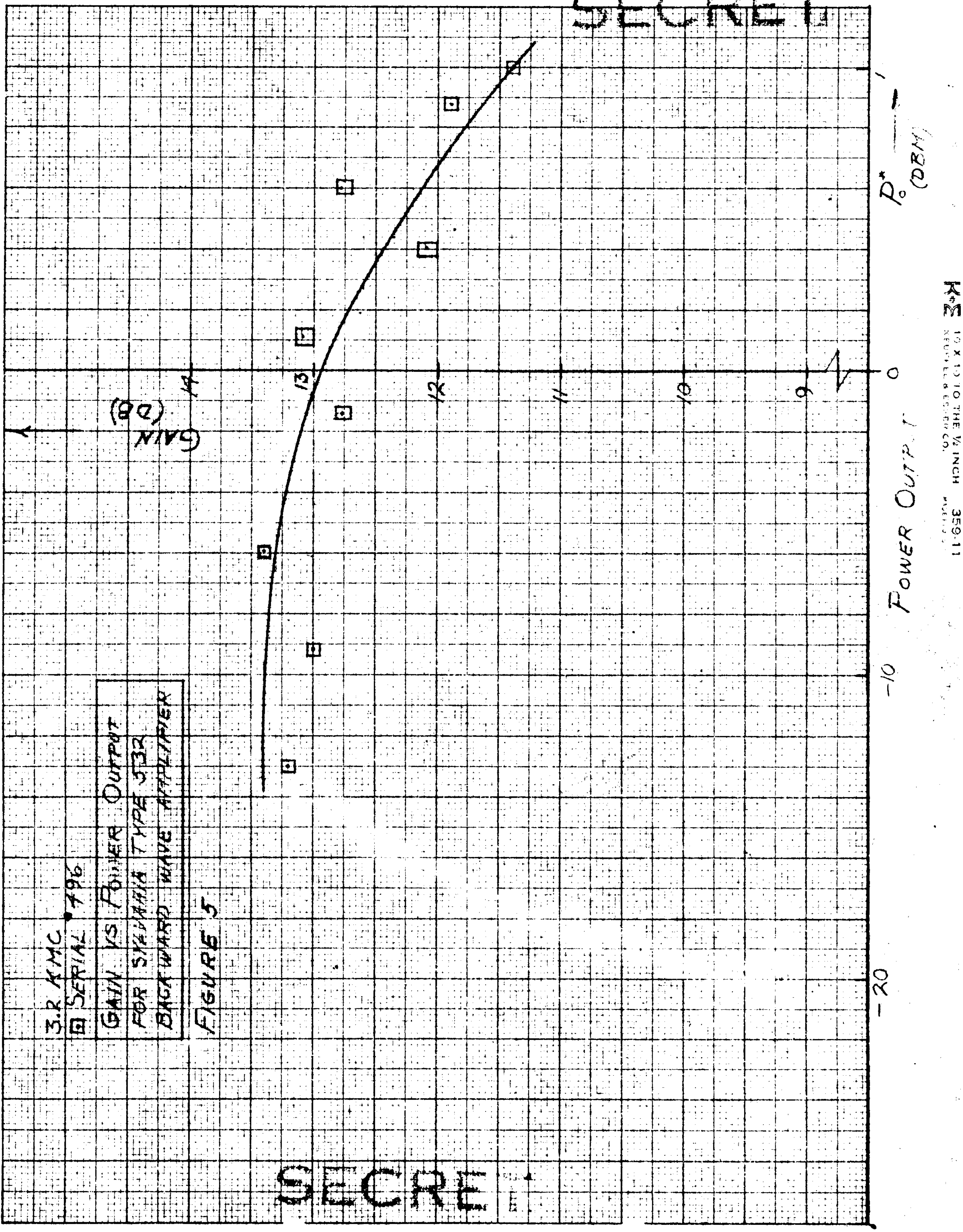

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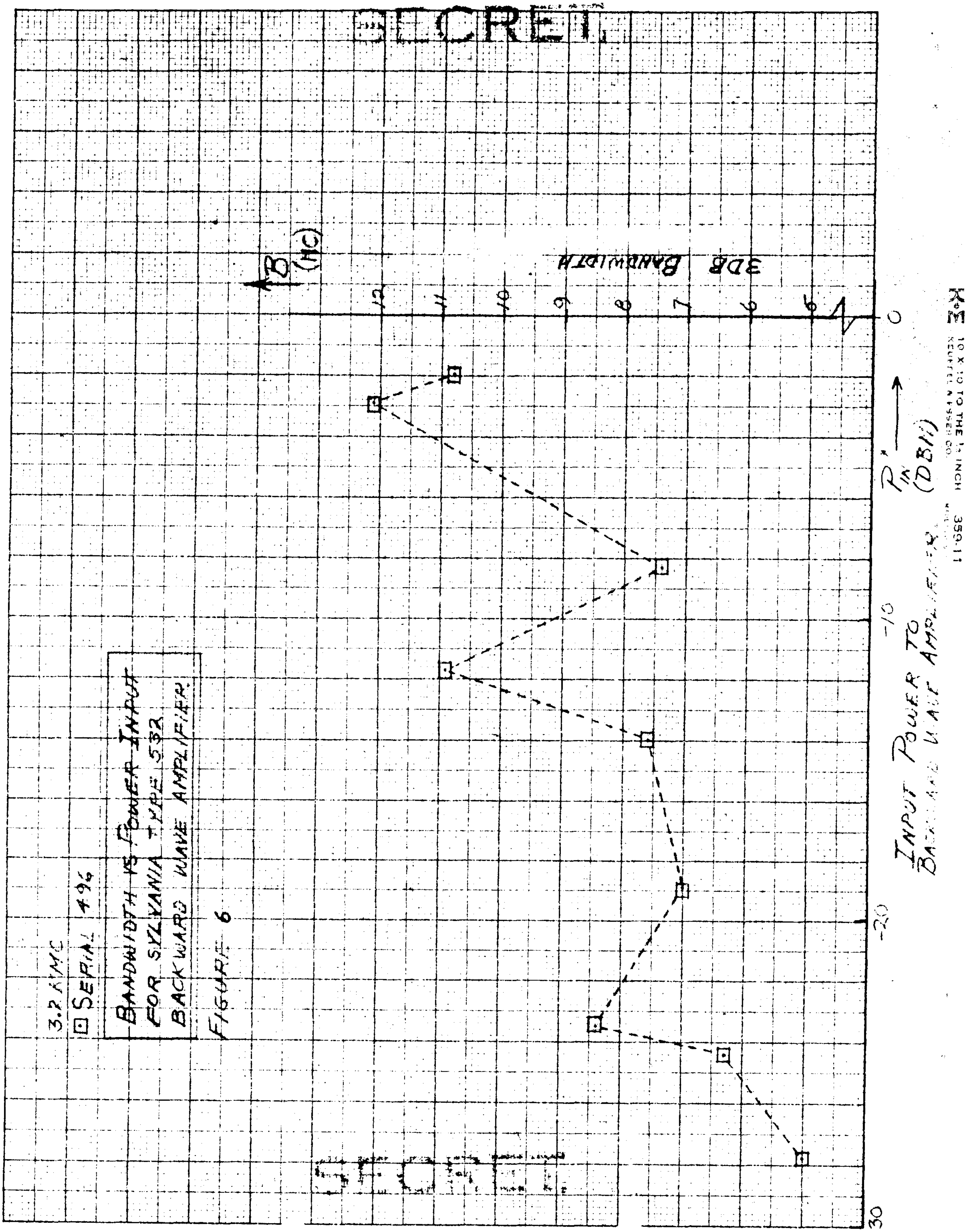

BANDWIDTH VS POWER INPUT FOR SYLVANIA TYPE 532 BACKWARD WAVE AMPLIFIER

FIGURE 6

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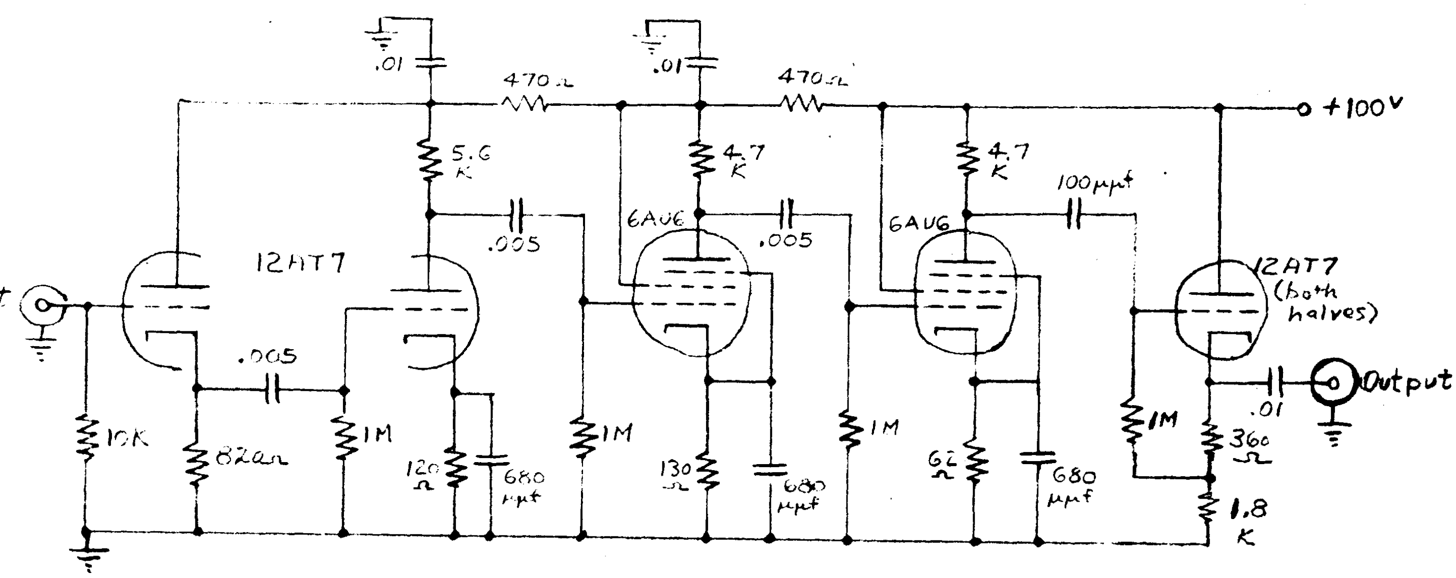

esistors carbon 1/2 watt 5%

pacitors in μf unless otherwise noted

FIGURE 7

VIDEO AMPLIFIER

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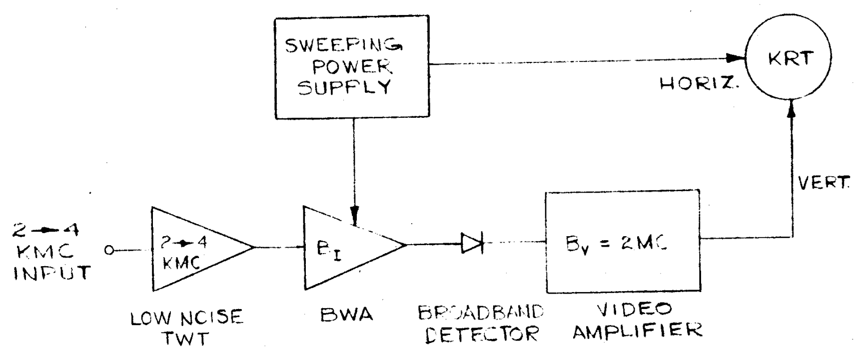

FIGURE 8 SWEPT CRYSTAL VIDEO RECEIVER

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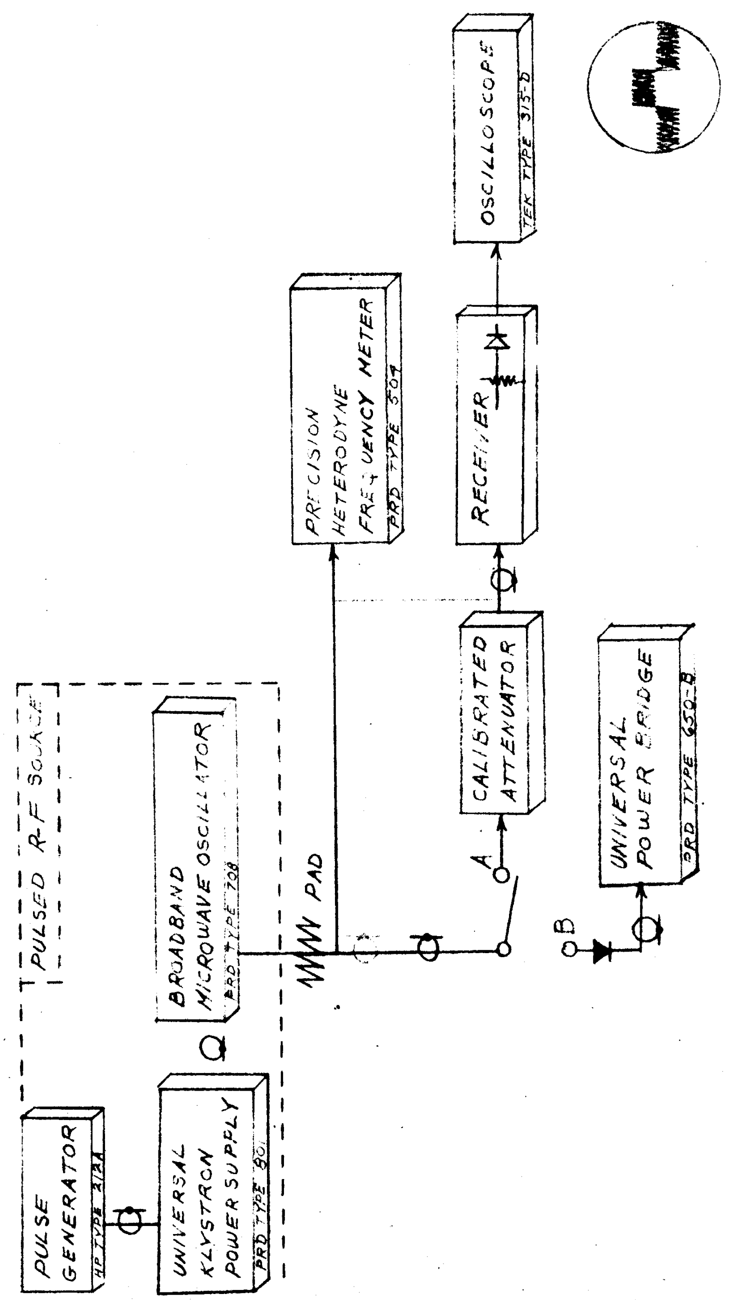

FIGURE 9 RECEIVER SENSITIVITY MEASUREMENT

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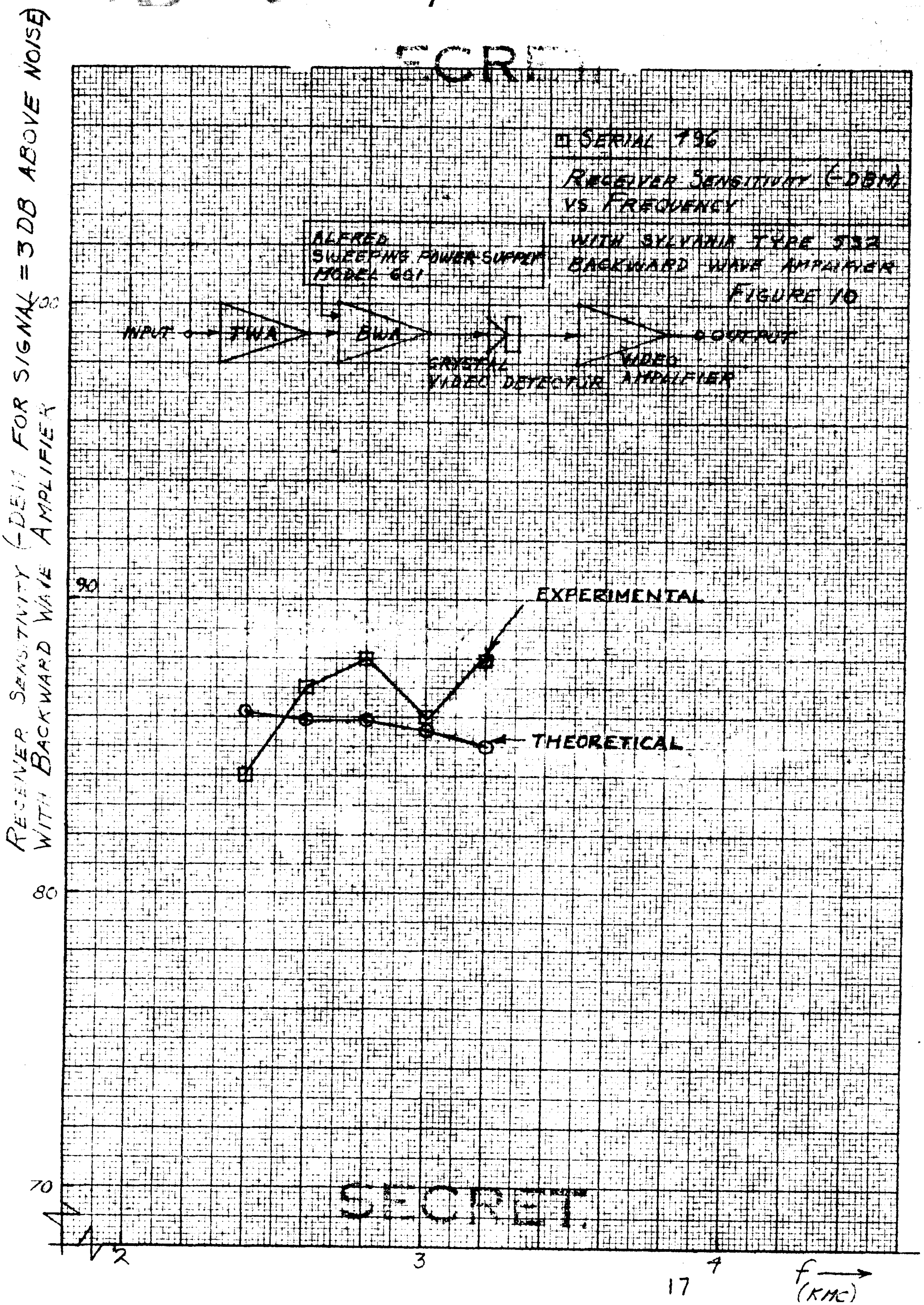

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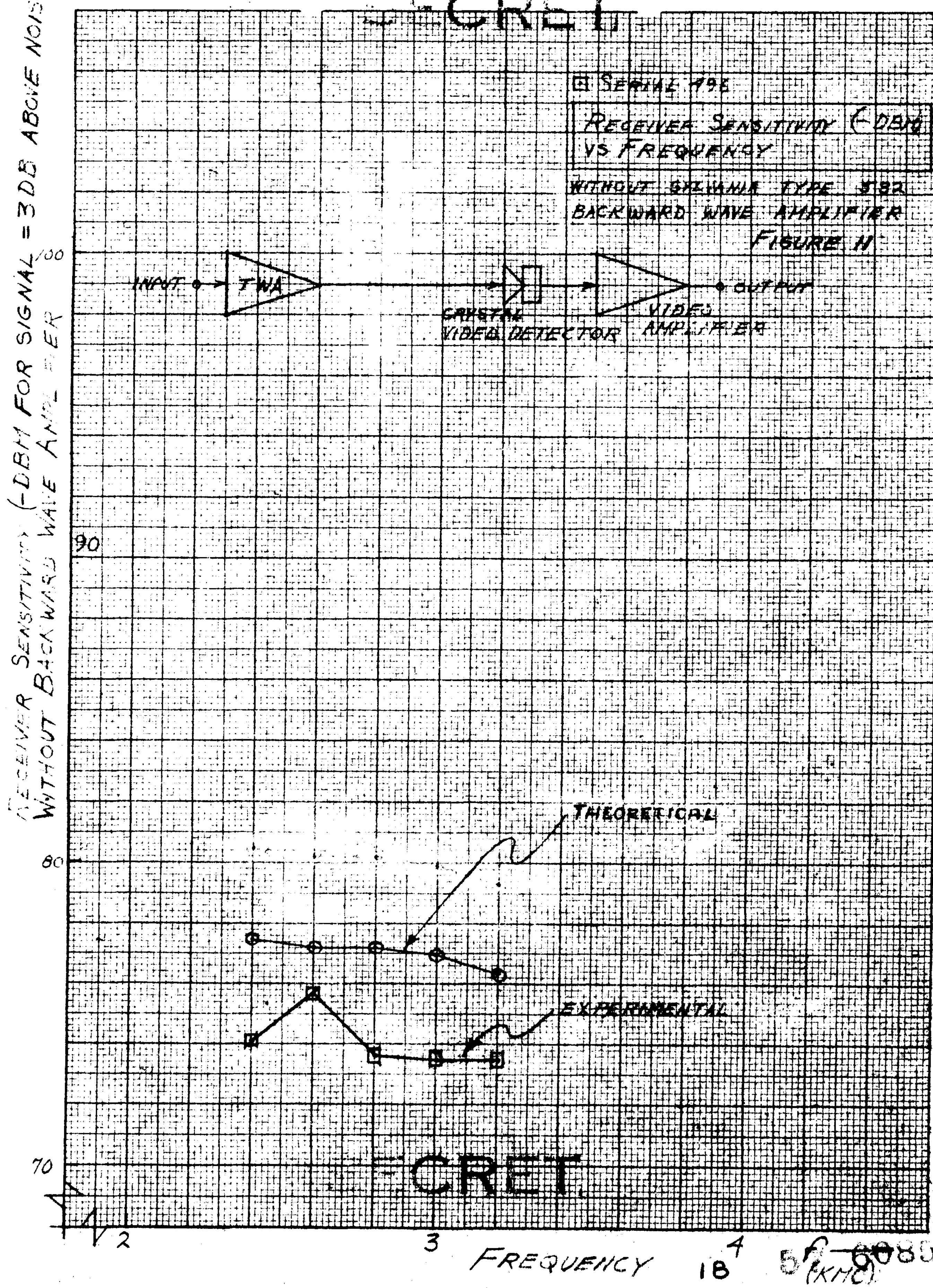

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